Tracking No	Time	Classification	Documentation		Subsystem
MER - 0	**MET:** 000:00:08	Problem	**FIAR**	**IFA** STS-29-V-01	OMS/RCS
PROP-01	**GMT:** 072:15:05		**SPR** 29RF02	**UA**	**Manager:**
			IPR 33RV-0023	**PR** PR03-0318	
					Engineer:

Title: Reaction Control Subsystem Thruster RIU Failed Off (ORB)

Summary: DISCUSSION: Reaction control system (RCS) thruster R1U failed off after Main Engine cutoff and prior to External Tank separation. During this mated coast period, the flight control system attempted to fire the thruster for attitude roll control, but a low chamber pressure caused the RCS redundancy management to deselect the thruster. A trickle current test was performed in-flight and postflight in the Orbiter Processing Facility, and both indicated that there were no open circuits in the valve's electrical path.

The thruster was removed and sent to the vendor for failure analysis. Deposits of iron nitrate were found on the pilot and mainstage poppets and seats. Iron nitrate deposits are formed because of corrosion of the pilot and mainstage poppets and seats by nitric acid. Nitric acid is formed in the thruster when the oxidizer combines with water. Water was most likely introduced into the thruster during ferry flight prior to STS-29 as a result of the poor condition of the ferry flight thruster nozzle plugs. The ferry flight thruster nozzle plugs lose their sealing effectiveness after 10 use cycles. KSC has only one set of ferry flight thruster nozzle plugs, which have been used since STS-1. Some of the nozzle plugs are in such bad shape that they will only stay in place in upward firing thrusters. Therefore, the nozzle plugs in the worst shape are more likely to be inserted in an upward firing thruster for ferry flight. Also loading procedures are conducive to introducing moisture into the thruster. CONCLUSION: The most probable cause of thruster R1U failure to fire was due to contamination of the pilot poppet and seat caused by exposure of the thruster to moisture during ferry flight. CORRECTIVE_ACTION: Thruster R1U was removed and replaced, and the vendor performed failure analysis on the thruster. An OMRSD change will be initiated to preclude the use of loose ferry flight plugs. This may require the procurement of additional plugs. EFFECTS_ON_SUBSEQUENT_MISSIONS: Thrusters may continue to fail off in the same manner, especially upward firing thrusters. The likelihood of failure is related to the amount of time the pod has been exposed to conditions conducive to allowing water or water vapor into the thrusters. Thrusters may also exhibit more reverse leakage during propellant loading because of contamination on the poppets and seals. This increased reverse leakage is an additional way of introducing water into the thruster and can aid existing corrosion or cause new corrosion.

Tracking No	Time	Classification	Documentation		Subsystem
MER - 0	**MET:**	Problem	**FIAR**	**IFA** STS-29-V-02	INST
A) MMACS-01, B) MMACS-03	**GMT:**		**SPR** A) 29RF03, B) 29RF14	**UA**	**Manager:**
			IPR C) 33RV-002	**PR** A) APU-3-09-0178, B) APU-3-09-0177, CEPD-3-09-1123	**Engineer:**

Title: Operational Instrumentation Failures. (ORB)

Summary: DISCUSSION: A. The auxiliary power unit (APU) 3 exhaust gas temperature (EGT) 2 (V46T0340A) dropped about 100 degrees during ascent, regained its normal reading, and dropped again after MECO. KSC will troubleshoot this sensor and remove and replace, if required. KSC OMI V1019 will verify proper operation. Failure analysis will be tracked by CAR 29RF02. This is a criticality 3 measurement. This problem is closed.

B. At APU shutdown postlanding, the APU 1 EGT 1 (V46T0142A) sensor became erratic, cycling between 270 degrees F and 930 degrees F. APU 1 EGT 2 indicated normal temperatures. KSC will troubleshoot this sensor and remove and replace, if required. KSC OMI V1019 will verify proper operation. Failure analysis will be tracked by CAR 29RF14. This is a criticality 3 measurement. This problem is closed. C. The Space Shuttle Main Engine (SSME) 3 power supply temperature was erratic from SSME start to shutdown. Troubleshooting at KSC found a wire that was pulled of the backshell of connector 50P446. KSC will repair and retest connector per F/D E41T3150A. This is a criticality 3 measurement. This problem is closed. CONCLUSION: See above. CORRECTIVE_ACTION: See above. EFFECTS_ON_SUBSEQUENT_MISSIONS: None

Tracking No	Time	Classification	Documentation		Subsystem
MER - 0	**MET:** 000:02:09	Problem	**FIAR**	**IFA** STS-29-V-03	FC/PRSD
EECOM-02	**GMT:** 072:17:06		**SPR** 29RF01	**UA**	**Manager:**
			IPR None	**PR**	
					Engineer:

Title: Erratic PRSD Cryogenic Hydrogen Tank 3 Pressure and Manifold Pressures (ORB)

Summary: DISCUSSION: During hydrogen tank 3 activation for on-orbit heater checkout, erratic manifold and tank pressures were observed, however the tank pressures remained within the control band of 220-240 psi. Manifold pressure showed several spikes of approximately 20-psi magnitude and one of 70 psi which peaked at 305 psi and opened the manifold relief valves. The 70-psi manifold pressure spike occurred about 2 minutes after a fuel cell purge was completed during tank 3 operations. The tank 3 heaters were deactivated after the purge. Tank 3 was turned on four and one-half hours later with only heater A to check heater operation. Tank and manifold pressures again displayed a similar pattern, but were somewhat less erratic. The tank was deactivated before the crew sleep period.

Data analysis showed that the system hardware was operating properly. The heaters, heater controller, and the check valve performed as expected. Review of STS-26 and STS-27 (same three-tank configuration) data revealed similar pressure behavior when tank 3 was operational. The STS 61-B mission with a four-tank-set configuration also experienced erratic pressure oscillations when tank 3 was operated singly. The oscillations disappeared when tank 4 was activated to share the flow requirements. This phenomenon is explained by transient heat transfer to the tank, high flow demand and high initial line heat leak, all of which combined to create a series of reactions. Transient heat transfer resulted in uneven heat distribution in the tank. Near the heater, the volume of fluid has a warmer temperature and lower density. Farther away toward the tank wall, the fluid volume is colder and denser. Most of the time, flow was from the cold dense volume and was steady. However, since the volume of the warmer fluid was continuously increasing, the warmer fluid gradually approached the supply line exit. Eventually flow from this volume began, initiating a mixing process. When flow demand was high (3 fuel cell supply and/or purge), sudden mixing produced a tank pressure drop even with the heaters on. At the same time, a sudden drop in the density of the fluid flowing into the manifold resulted. Since the less dense fluid was more sensitive to heat leak, manifold pressure rose quickly, closing the check valve and shutting off flow. The intermittent surge flow due to periodic closing and opening of the check valve further complicated the tank pressure signature. The high flow when the check valve opened increased the tank pressure drop. The no-flow condition when the check valve was closed, combined with residual heat from the heaters and the tank wall, caused a pressure rise even with the heaters off. The final large manifold pressure spike was the result of a large volume of hydrogen trapped in the line after the fuel cell purge that expanded as it was heated. The tank pressure signature was expected to smooth out at lower density as mixing would be more gradual and heat distribution would be more even. A combination of these conditions and the fact that the manifold became cooler with time tended to eliminate manifold pressure spikes. Since no hardware failure occurred and the manifold relief valves could safely relieve manifold pressure in case another large spike occurred, hydrogen tank 3 was placed back into normal operation for the remainder of the STS-29 mission. As expected, the pressure signatures improved and returned to normal as the tank 3 quantity decreased. CONCLUSION: The erratic pressure signatures experienced are normal hardware responses to operating from tank 3 alone when it is near full. CORRECTIVE_ACTION: The flight data file procedures have been updated to prevent feeding three fuel cells and performing a fuel cell purge with a single tank at high quantity. This will eliminate the high-flow condition responsible for the erratic signatures. EFFECTS_ON_SUBSEQUENT_MISSIONS: None.

Tracking No	**Time**	**Classification**	**Documentation**		**Subsystem**
MER - 0	**MET:** 000:00:00	Problem	**FIAR**	**IFA** STS-29-V-04	MPS
BSTR-01	**GMT:** 072:14:57		**SPR** 29RF08	**UA**	**Manager:**
			IPR	**PR** MPS-3-09-0062	
					Engineer:

Title: MPS GOX Flow Control Valves E1 and E3 Sluggish (ORB)

Summary: DISCUSSION: The main propulsion system (MPS) gaseous oxygen (GOX) flow control valves (FCV's) E1 and E3 exhibited delayed response times for the first opening cycle during the main engine start transients. FCV E1 delayed initiating the opening approximately 0.5 second after the open command was given, whereas the specification allows only 0.4 second. Subsequent operations of FCV E1 during the mission were nominal. FCV E3 delayed the initiation of opening by approximately 1.5 seconds after receiving the open command, then required an additional 1.5 seconds to reach the open position. Normal opening time should be no more than 0.2 second.

As a result of the delayed opening response of these valves, the pressure within the External Tank (ET) liquid oxygen (LOX) tank reached the lowest value recorded on any Shuttle flight. The pressure decreased to 15.5 psig (measured) at lift-off plus 7 seconds, whereas the previous recorded lowest pressure had been 16.2 psig (measured). Requirements specify a minimum pressure of 12.4 psig. Sluggish FCV's were observed during the STS-26 Flight Readiness Firing and mission. Inspection of the valves revealed particulate contamination and associated gauging. The slow valve response times were attributed to the combined effect of contamination and attempted operation during the thermal transient environment experienced after engine start. The thermal transient, in which the valve thermal environment changes from coldsoak conditions to hot gas flow, induces a brief period of material deformation that sufficiently reduces the internal clearance between the valve's internal poppet and sleeve so as to allow contaminant to cause binding. Continued hot gas flow thermally stabilizes the valve and causes the clearances to increase, thus decreasing or eliminating the contaminant interference with movement. Recent testing at the White Sands Test Facility of the GOX FCV under combined flight contamination levels and thermal transient conditions has been unsuccessful in replicating the flight anomalies, indicating that a third effect such as thrust structure loading may also be contributing to the valve distortion. Although a nominal valve response was observed during STS-27, a postflight electrical test caused one valve to stick. Inspection of the FCV's revealed that contamination was present. Postflight inspection of the STS-29 valves revealed particulate contamination similar in size and material type to that found after STS-26, but in less quantity. CONCLUSION: The combination of GOX valve deflections due to thermal gradients present after main engine start, possible valve deflections from thrust structure loading or other contributing factors, and contamination probably caused partial binding between the poppet and sleeve. This binding was eliminated as the valves were thermally stabilized by the continued hot gas flow. CORRECTIVE_ACTION: All three flow control valves were removed. Following cleaning and repolishing of each valve bore, the valves were returned to flight status. The GOX lines of OV-102 were purged with gaseous nitrogen, thus removing a significant amount of contamination. This purge will be performed before the next flight of OV-103 to verify system cleanliness. For STS-30, the ground-controlled prelaunch ET LOX tank ullage pressure was lowered 2 psig which allowed the FCV's to remain open during the main engine start transient. This pre-pressurization level will be utilized on all upcoming missions. EFFECTS_ON_SUBSEQUENT_MISSIONS: None.

Tracking No	Time	Classification	Documentation		Subsystem
MER - 0	**MET:** 000:06:22	Problem	**FIAR**	**IFA** STS-29-V-05	D&C - Panels
INCO-01	**GMT:** 072:21:19		**SPR** 29RF05	**UA**	**Manager:**
			IPR 33RV-0026	**PR** DDC-3-09-0051	
					Engineer:

Title: Payload Interrogator Lost Lock (ORB)

Summary: DISCUSSION: Eight minutes after payload deployment at 072:21:18 G.m.t. the Payload Interrogator (PI) lost communications lock with the Inertial Upper Stage (IUS). Telemetry indicated channel 006 was selected instead of the expected 906. The crew cycled the panel select thumbwheel switch on panel A1L, and the PI/IUS communications lock was re-established. No further problems occurred during the remainder of the mission. The problem could not be duplicated during postflight troubleshooting at KSC.

CONCLUSION: The most probable cause of the anomaly was an intermittent contact condition within the panel select thumbwheel switch that cleared when the switch was cycled. CORRECTIVE_ACTION: The thumbwheel switch on panel A1L was removed, replaced, and returned to the Orbiter prime contractor for failure analysis. The results of this activity will be tracked via CAR 29RF05. EFFECTS_ON_SUBSEQUENT_MISSIONS: None, pending the results of failure analysis.

Tracking No	Time	Classification	Documentation		Subsystem
MER - 0	**MET:** Prelaunch	Problem	**FIAR**	**IFA** STS-29-V-06	MPS
BSTR-03	**GMT:** Prelaunch		**SPR** 29RF06	**UA**	**Manager:**
			IPR None	**PR**	
					Engineer:

Title: Excessive Vapor At ET/Orbiter Umbilical (ORB)

Summary: DISCUSSION: An excessively large vapor cloud was observed emanating from the External Tank (ET)/Orbiter umbilical region beginning with propellant tanking operations and continuing through lift-off. This phenomenon was accompanied by an ice buildup around the umbilical and the presence of a dripping cryogenic liquid that produced vapor trails (streamers).

A review of postflight data and films showed that the amount of vapor/ice present was primarily a function of the pressure in the liquid hydrogen (LH2) system. During LH2 fast-fill and reduced fast-fill operations, heavy vapor and ice formation was observed. The condition was unaffected by the reduction in LH2 flowrate that accompanied reduced fast-fill operations. During the topping to 100 percent fill operation, the ET LH2 ullage pressure was reduced from 43-48 psia to 18 psia. This produced a rapid (though not complete) melting of ice and a reduction in the severity of the vapor cloud. During the LH2 replenish period, the vapor cloud remained less intense, the ice formation stabilized, and no cryogenic drops could be seen falling from the umbilical. When ET prepressurization occurred at T-1 minute 57 seconds, the LH2 system pressure increased approximately 30 psid and an obvious increase in vapor cloud intensity occurred. An upward jet of vapor also appeared at this time. At main engine ignition, a heavy vapor cloud was visible along with cryogenic drops emanating from the LH2 umbilical area. The substantial vapor cloud remained throughout Solid Rocket Booster ignition and ascent until the LH2 umbilical was lost from camera view after clearing the launch tower. Long range tracking cameras were inconclusive. The existence of the vapor cloud, ice and cryogenic drops were detected and verified only by visual methods. None of the leak detectors registered on abnormal LH2 quantity. The severity of the vapor cloud was aggravated by the high relative humidity (86 percent) existing during the launch operations time frame. This vapor cloud condition did not occur on the liquid oxygen system. Extensive postflight testing was performed to determine the phenomenon that would produce the vapor cloud, cryogenic streamers and vapor jets. The two most probable causes were a thermal short or an LH2 leak. The thermal short theory was plausible because of rework performed prior to flight on the insulating foam on the ET side of the LH2 umbilical. This could have provided a crack in the foam that permitted a thermal short. Testing showed that a geyser-like stream of vapor, similar to that seen prelaunch, could erupt from an opening in the insulation surrounding a cryogenic pipe. While it was shown that a thermal short could produce a vapor cloud and cryogenic drops, it was believed that the heat transfer changes within the umbilical during an LH2 pressure reduction were insufficient to account for the observed quantity of ice melting and cessation of cryogenic drop production. Several factors supported an LH2 leak. The vapor cloud intensity, ice buildup, and streamer production were a direct function of pressure of the LH2 system. The joint between the ET 17-inch feedline and disconnect were reworked prior to flight. Marshall Space Flight Center testing showed that an LH2 leak produced cryogenic drops (composed of solid/liquid air slush) with vapor streamers. During the STS-26 Flight Readiness Firing (FRF), a heavy vapor emanating from the LH2 umbilical was observed. For this FRF, the LH2 umbilical cavity was equipped with special instrumentation which registered a hydrogen leak within the umbilical. Analysis based on the location of the leak detectors within the umbilical cavity concluded that the leak was most probably from the 4-inch LH2 recirculation valve. The cause of the leak was undetermined, but an assumption attributed the leak to a faulty seal between the Orbiter and ET mating surfaces. The leak was deemed to be small enough to be no constraint to the flight of STS-26. The 4-inch valve was not removed postflight. Following STS-29, the 4-inch LH2 recirculation valve was removed and inspected. The Belleville spring cavity was grossly contaminated with LH2 line insulation closeout foam. The foam apparently seeped into this normally clear area during the valve's flange installation closeout foaming. Normally, this 4-inch valve assembly rotates slightly (angulates) during ET/Orbiter umbilical mating to correct for the load-induced deflection of the sealing surfaces. (Three hold-down bolts surround the 17-inch valve to produce parallel sealing surfaces at this critical interface. The remaining parts of the umbilical are not individually bolted together, but are cantilevered off of the umbilical halves. The reactive loads of the 2-inch valve, 4-inch valve, and electrical monoball cause approximately 0.08 inch deflection at the 4-inch disconnect valve. This deflection requires approximately 0.6 degree of angulation of the Orbiter 4-inch valve assembly to maintain a parallel interface.) If the foam was of sufficient quantity and positioning to restrict proper angulation, a path for LH2 leakage through the sealing surface gap into the helium purged gap between the ET/Orbiter umbilical plates could exist. In support of this scenario, STS-29 data reveal that the vapor cloud occurred within 30 seconds of LH2 exposure to the 4-inch valve. The 17-inch LH2 line had been pressurized and at cryogenic temperature for several minutes, however, and is considered unlikely to be the source of the vapor cloud. Unfortunately, the foam in the 4-inch valve assembly was removed before an attempt to repeat the leakage was made. Leak tests involving attempts to duplicate the foaming conditions have thus far been unable to produce the leakage observed. The precise positioning of the valve in the umbilical and the thickness of the foam are unknown. Therefore, it is difficult to reproduce the precise conditions existing during STS-29 that may be necessary to duplicate the problem. CONCLUSION: The vapor cloud observed during the STS-29 prelaunch period was most probably caused by an LH2 leak at the ET/Orbiter interface of the 4-inch LH2 recirculation valve. This leakage was most probably the result of improper foam seepage preventing the necessary angulation of the 4-inch valve assembly. The existence of a thermal leak through a cracked foam insulation, as well as the presence of high humidity, may have contributed to the phenomenon. CORRECTIVE_ACTION: The foam closeout and inspection procedures were modified to prevent recurrence of the foam seepage. Hydrogen leak detectors were added to the ET/Orbiter 17-inch umbilical area. A Launch Commit Criteria change was approved to define go/no-go criteria using launch pad camera observations and indications from the new leak detectors. No-go conditions were established to be H2 leak detectors reading > 2 percent, unusual vapors and liquid droplets observed and the H2 detector reading > 1 percent, or unusual vapors and liquid droplets observed with the H2 leak detector determined to be failed. Inspections of the 4-inch LH2 recirculation valves in OV-104 and OV-102 were performed.

While OV-104 had no excess foam, OV-102 had excess foam present, but in a less amount than observed on OV-103, and it was removed prior to STS-28. EFFECTS_ON_SUBSEQUENT_MISSIONS: None.

Tracking No	Time	Classification	Documentation		Subsystem
MER - 0	**MET:**	Problem	**FIAR** JSC-EE-0649	**IFA** STS-29-V-07	TAGS
INCO-03, INCO-05	**GMT:** 73:19:28		**SPR**	**UA**	**Manager:**
			IPR None	**PR**	
					Engineer:

Title: Test and Graphics System Hardcopier Developer Overtemperature Indication.Spontaneous Text and Graphics System Hardcopier Status Change. (ORB)

Summary: DISCUSSION: At about 073:19:28 G.m.t., the Test and Graphics System (TAGS) developer overtemperature telemetry point latched, indicating that one of the three developer heaters had exceeded its overtemperature threshold setting and had automatically shut off. A few minutes later, the temperature-normal telemetry point indicated a low developer temperature verifying that the developer heater had shut off correctly. The power was cycled off then back on to reset the overtemperature latch. The overtemperature indication recurred 16 minutes later and the power was again cycled to reset the latch. At about 074:03:10 G.m.t., the overtemperature indication occurred again. Before cycling power to reset an all-black test page was transmitted to determine which heater had shut off. The crew later reported that the center of the test page was significantly lighter than the edges indicating that the center heater had shut off.

Power was cycled to reset the latch and normal TAGS operations resumed. The TAGS was subsequently powered off when not in use to reduce the chance of recurrence of an overtemperature indication. There was no adverse effect on the mission. Postflight examination of the TAGS messages showed no evidence of image overprocessing as would be expected from a higher-than-normal developer temperature. This indicates that the overtemperature indications were erroneous and were not due to true overtemperature conditions in the developer. At about 074:10:15 G.m.t., and again at about 074:10:28 G.m.t., while configured in the "READY" state and receiving a message transmission, the TAGS hardcopier spontaneously changed its status to "STANDBY". In both cases, the hardcopier was reconfigured to "READY" and the interrupted message was successfully retransmitted and received. There was no adverse effect on the mission. This anomaly has been simulated by momentarily moving the hardcopier paper away from the paper-empty sensor during transmission of a message. The transient detection of an empty condition by the sensor causes the hardcopier to immediately transition to "STANDBY", as it is designed to do, and to remain in that status until commanded to "READY". If the paper-empty sensor is adjusted to be too sensitive, relatively minor fluctuations in paper position can cause an erroneous detection of the paper-empty state. A design change is currently in work to eliminate the "STANDBY" function from the TAGS. CONCLUSION: The most likely cause of the overtemperature indications is either transient electrical noise from the developer slip-ring or the overtemperature detection threshold in the developer control electronics being adjusted too low. The most likely cause of the spontaneous hardcopier status change is an oversensitive setting of the paper-empty sensor. CORRECTIVE_ACTION: The TAGS hardcopier, Part No. AV14453, Serial No. 003, was removed, replaced, and is undergoing failure analysis. The results of this effort will be tracked via FIAR JSC-EE-0649. EFFECTS_ON_SUBSEQUENT_MISSIONS: None, pending results of failure analysis.

Tracking No	Time	Classification	Documentation		Subsystem
MER - 0	**MET:** 001:10:01	Problem	**FIAR** B-FCE-029-F009	**IFA** STS-29-V-08	OI - Recorders
INCO-04	**GMT:** 074:00:58		**SPR**	**UA**	**Manager:**
			IPR	**PR** INS-A-0020	
					Engineer:

Title: Inability to Dump OPS Recorder 2 Track 4 Data. (GFE)

Summary: DISCUSSION: At 074:00:58:30 G.m.t., a dump was commanded from the OPS 2 recorder beginning at track 5. When the recorder switched to track 4, data were noisy and synchronous lock could not be acquired. The following information is known:

a. The dumped data from tracks 3 and 5 were "good". b. Attempts to dump track 4 both forward and reverse at more than one site did not produce usable data. c. A subsequent attempt to again record on track 4 in the forward direction (0 to 10 % of tape) produced no usable data. Troubleshooting isolated the problem to the transport unit. The heads were inspected and did not appear dirty, however, the tape was backed away from the heads and the heads were cleaned. Further troubleshooting appears to have isolated the problem to a bad solder joint at the input side (from track 4) to the intermediate amplifier board. Analysis to confirm this failure scenario continues. CONCLUSION: The most probable cause of the inability to dump track 4 data was a cold solder joint at the input side to the intermediate amplifier board. CORRECTIVE_ACTION: Remove and replace the OPS 2 recorder. The OPS 2 recorder serial number (S/N) 1019 was removed on April 10 and sent to the vendor for repair. This recorder has been replaced with S/N 1018. EFFECTS_ON_SUBSEQUENT_MISSIONS: None.

Tracking No	Time	Classification	Documentation		Subsystem
MER - 0	**MET:** 004:20:02	Problem	**FIAR**	**IFA** STS-29-V-09	MECH
MMACS-02	**GMT:** 077:10:59		**SPR** 29RF07	**UA**	**Manager:**
			IPR 33RV-0025	**PR** MEQ-3-09-0412	
					Engineer:

Title: Payload Bay Door Port B Closure Indication Failure. (ORB)

Summary: DISCUSSION: During payload bay door closure at approximately 077:10:59 G.m.t., the port aft ready-to-latch indicator continued to indicate on when it should have indicated closed. The failure was duplicated at KSC. Troubleshooting verified a switch module problem. The module was removed and replaced. The removed module was sent to the contractor for an engineering evaluation to determine the exact cause of the failure. A determination was made that the indication was incorrect because of a deficient switch contact. The Haydon switch has been removed from the module subassembly for more detailed testing. The module has been reworked for a spare; all of the switches in the subassembly have been replaced with Particle Impact Noise Detection (PIND) tested switches.

CONCLUSION: The indicator failed to indicate properly because of a deficient switch contact. CORRECTIVE_ACTION: The module was removed and replaced with a module that contained PIND tested switches. EFFECTS_ON_SUBSEQUENT_MISSIONS: None.

Tracking No	Time	Classification	Documentation		Subsystem
MER - 0	**MET:** 000:00:03	Problem	**FIAR**	**IFA** STS-29-V-10	HYD
None	**GMT:** 072:15:00		**SPR** 29RF09	**UA**	**Manager:**
			IPR	**PR** HYD-3-09-0284	
					Engineer:

Title: Water Spray Boiler 3 GN2 Low Relief Valve Reseat Pressure. (ORB)

Summary: DISCUSSION: After the water spray boiler (WSB) 3 gaseous nitrogen (GN2) relief valve allowed the GN2 pressure to be properly relieved during ascent, the relief valve reseated at 26.7 psia upon reaching orbit with no subsequent leakage. The Operational Maintenance Requirements and Specifications Document (OMRSD) specifies the minimum reseat pressure as 28.0 psia. This occurrence had no impact on the mission.

Although the OMRSD limit for relief-valve reseat pressure is 28.0 psia, this is primarily applicable to steady-state ground checkout conditions. The dynamic conditions present during ascent, such as vibration, may affect the reseat parameters of a properly functioning relief valve, causing it to reseat at a decreased pressure. CONCLUSION: The water spray boiler 3 GN2 relief valve most probably reseated at a lower pressure due to the dynamic conditions present during ascent. The relief valve is considered to have been functioning properly. CORRECTIVE_ACTION: The water spray boiler 3 relief valve will be leak-tested during turnaround operations. Out-of-specification leakage will result in the removal and replacement of the valve. A File IX OMRSD change to allow a minimum reseat pressure of 26.0 psia has been initiated. EFFECTS_ON_SUBSEQUENT_MISSIONS: None.

Tracking No	Time	Classification	Documentation		Subsystem
MER - 0	**MET:** 000:00:14	Problem	**FIAR**	**IFA** STS-29-V-11	HYD
None	**GMT:** 072:15:11		**SPR** 29RF10	**UA**	**Manager:**
			IPR	**PR** HYD-3-09-0285	
					Engineer:

Title: Water Spray Boiler 1 GN2 Relief Valve Leak (ORB)

Summary: DISCUSSION: Water spray boiler (WSB) 1 gaseous nitrogen (GN2) pressure regulator relief valve leakage was observed after GN2 isolation valve closure following auxiliary power unit shutdown at 072:15:11:07 G.m.t. The regulator pressure exhibited a steady decay rate of 0.061 psia/hr for 49 hours, at which time the decay stopped. The calculated allowable leak rate is 0.04 psi/hr. This leak had no impact on the mission.

The nitrogen pressure tank is isolated by the GN2 shutoff valve when the water spray boiler is not functioning. This assures retention of the nitrogen source pressure should manifold leaks such as this occur. Currently, the Operational Maintenance Requirements and Specifications Document (OMRSD) specifies a 0.6 psi/hr maximum leak rate. Although this requirement is based on the shutoff valve being open, the OMRSD does not specify this condition. Using similar criteria with the valve closed and the 118 lb water tank load present on this mission, the equivalent allowable leak rate is 0.04 psi/hr. This condition has been seen on previous missions (STS-8, STS 51-J, STS 51-A, and STS-26) where it was attributed to the GN2 relief valve not properly seating after ascent. CONCLUSION: The water spray boiler 1 GN2 regulator pressure most probably decayed because the relief valve did not properly seat after ascent. CORRECTIVE_ACTION: The water spray boiler 1 relief valve will be leak-tested during turnaround operations. Out-of-specification leakage will result in the removal and replacement of the valve. A File III OMRSD change will be submitted to perform leak checks with the shutoff valve closed, for which allowable leak rates will be 0.3 psi/hr on the high pressure side and 0.06 psi/hr on the low pressure side. A File IX OMRSD change to allow a leak rate of 0.1 psi/hr during the mission will be submitted. EFFECTS_ON_SUBSEQUENT_MISSIONS: None.

Tracking No	Time	Classification	Documentation		Subsystem
MER - 0	**MET:** Postlanding	Problem	**FIAR**	**IFA** STS-29-V-12	MPS
None	**GMT:** Postlanding		**SPR** 29RF11	**UA**	**Manager:**
			IPR	**PR** MPS-3-09-0673	
					Engineer:

Title: Main Propulsion System LH2 17-Inch Disconnect Audible Leak (ORB)

Summary: DISCUSSION: An audible leak emanating from the main propulsion system (MPS) liquid hydrogen (LH2) 17-inch disconnect was discovered during a postflight inspection at Edwards AFB. Following return of the Orbiter to the Kennedy Space Center a leak check was performed with the flapper valve remaining in the closed (post-landing) position. A leak rate of 1086 scim was measured. The allowable leakage is 1000 scim. Following the test, the flapper valve was opened and inspected. No contamination was found; however, several nicks and scratches were noted. None of these marks were properly aligned or of sufficient size to account for the measure leak rate. Additionally, a review of photographs taken prior to the mission revealed that all defects had existed prior to this incident.

After cleaning the surfaces of the flapper valve seal and seat, the flapper valve was closed and another leak check was performed. This produced a 209-scim leak rate. When the flapper valve was closed prior to External Tank separation, the valve was surrounded by cryogenic fluid. The presence of this fluid caused the valve to close at a slower rate than that achieved when no fluid was present. The valve closure performed at KSC was done without the presence of fluid and this produced a rapid valve closure that "settled-in" the flapper and yielded a tighter seal. This anomaly had no impact on the mission. CONCLUSION: Contamination on the sealing surface of the flapper valve combined with the slower valve closure rate due to the presence of cryogenic fluid most probably caused the leakage. CORRECTIVE_ACTION: The sealing surfaces of the flapper valve were cleaned. A subsequent leak check produced results well within requirements. EFFECTS_ON_SUBSEQUENT_MISSIONS: None.

Tracking No	Time	Classification	Documentation		Subsystem
MER - 0	**MET:** 000:00:08	Problem	**FIAR**	**IFA** STS-29-V-13	MPS
BSTR-04	**GMT:** 072:15:05		**SPR** 29RF12	**UA**	**Manager:**
			IPR 33RV-0028	**PR**	
					Engineer:

Title: LH2 4-Inch Disconnect Valve Failed to Pneumatically Close (ORB)

Summary: DISCUSSION: After the liquid hydrogen (LH2) 4-inch disconnect valve was commanded to close following main engine cutoff, the close indication (V41X1420E) was not received for 5.27 seconds. The specification for maximum valve closing time is 2.30 seconds. Data shows that the close indication was received shortly after the command to perform External Tank (ET)/Orbiter umbilical separation was issued.

The 4-inch LH2 disconnect valve normally closes pneumatically after receiving the close command. A backup system exists, however, in which the valve is mechanically attached to the ET/Orbiter umbilical plates separation system. This backup system mechanically closes a failed-open valve when the umbilical plates are separated prior to ET separation. The data for this flight are consistent with valve closure via the backup mechanical system. This event had no affect on the mission. When the 4-inch LH2 valve assembly was tested during post-flight failure analysis, the valve would not close when cooled to LH2 temperature. When allowed to warm, the valve closed satisfactorily. A subsequent test at LH2 temperature produced an unmovable valve. When the valve actuator was replaced, the valve closed satisfactorily at LH2 temperature. Following the STS-26 mission (OV-103 flight 7), the flapper seal on this valve was replaced and the flapper assembly reshimmed in response to a leak (flight problem STS-26-14). An LH2 vapor cloud was experienced on STS-29 that is believed to have emanated from the 4-inch LH2 valve assembly due to seepage of insulating foam into the Belleville spring cavity (flight problem STS-29-06). It is believed that neither of these occurrences are related to the problem described in this report.
CONCLUSION: The failure of the LH2 4-inch disconnect valve to pneumatically close was probably due to a thermally induced problem with the valve actuator.
CORRECTIVE_ACTION: The LH2 4-inch disconnect valve was removed and replaced. The suspect actuator will undergo failure analysis.
EFFECTS_ON_SUBSEQUENT_MISSIONS: None.

Tracking No	Time	Classification	Documentation		Subsystem
MER - 0	**MET:** 004:19:43	Problem	**FIAR**	**IFA** STS-29-V-14	Active Thermal Control Subsytem
None	**GMT:** 077:10:40		**SPR** 29RF13	**UA**	
			IPR 33RV-0029	**PR** ECL-3-09-0618	**Manager:**
					Engineer:

Title: FES Primary Controller B Outlet Temperature Oscillation (ORB)

Summary: DISCUSSION: During the STS-29 mission, the flash evaporator system (FES) control temperature was observed to be oscillating between 38 and 41?F and then damping out in approximately six cycles during three different FES startups. These oscillations were within the 37 to 41.5?F control band of the FES, therefore, FES shutdown was not experienced as a result of the oscillations. During entry, a normal and understood FES control temperature transient occurred when the crew switched the FES primary B controller from "ON" to "GPC". This transient, coupled with an upward startup oscillation, caused a FES over-temperature shutdown at approximately 077:10:40 G.m.t. The crew recycled the primary controller B switch and successfully restarted the FES which functioned normally for the remainder of the mission.

The cause of the FES oscillation was initially believed to be a problem in either the primary B FES outlet temperature controller or the primary B midpoint temperature sensors. However, troubleshooting at KSC revealed that these sensors responded properly. Further investigation revealed that the OV-103 FES midpoint sensor block had been modified to have a smaller Freon flow path through the block. Thermal response tests were performed on both the OV-103 and the unmodified OV-102 FES midpoint sensor blocks. These data verified that the OV-103 midpoint sensor block had a slower thermal-response time that contributed to the oscillation and subsequent shutdown. CONCLUSION: The FES primary B controller temperature oscillations were most probably cuased by a thermal lag in the modified OV-103 midpoint sensor block. CORRECTIVE_ACTION: The OV-103 FES midpoint temperature sensors were repacked in thermal grease and copper beads at a high pressure to improve the response time of the sensors. The OV-103 midpoint sensor block will be flown as-is with the repacked sensors. Data from the next OV-103 mission will be analyzed to determine if the modified sensor block exhibits any oscillation with the repacked sensors. If the FES oscillations recur, a problem will not result at either high or low heat loads since the oscillations encompass only a few degrees and last only a few seconds. Even if the FES shuts down because of these oscillations, it can be easily restarted on any of the primary or secondary controllers. EFFECTS_ON_SUBSEQUENT_MISSIONS: None.

Tracking No	**Time**	**Classification**	**Documentation**		**Subsystem**
MER - 0	**MET:** 004:04:40	Problem	**FIAR**	**IFA** STS-29-V-15	GNC
GNC-01	**GMT:** 076:19:37		**SPR** 29RF15	**UA**	**Manager:**
			IPR	**PR** STR-3-09-3031	
					Engineer:

Title: An Approximate 0.5 Degree Discrepancy was Observed Between Two Crew Optical Alignment Sight (COAS) Calibrations. (ORB)

Summary: DISCUSSION: A +X crew optical alignment sight (COAS) calibration was performed on flight day (FD) 3. On FD 5, three +X COAS calibrations were performed, and these calibrations differed from the FD 3 calibration by 0.5 to 0.6 degree in the -Y direction. The requirement is for the difference to be less than 0.12 degree.

Ground testing has included verification of the COAS alignment utilizing an alignment jig at Rockwell-Downey, and a detailed inspection of the adapter plate. In addition, the +X mounting surface (panel 01) was measured for the required interface flatness and a fit check performed between the +X adapter plate and the panel. The fit check indicated that the plate was difficult to mount and a 0.004-inch gap was measured across the lower plate to panel interface. As a result of these findings, the guide pins and guide pin holes were measured and compared against the specifications. The guide pins were found to be within specification (specification = 0.2490 ? 0.0005 inch, and the pins measured 0.2488, 0.2487 and 0.2488 inch); however, all of the guide pin holes were found to be smaller than specification (specification = 0.2525 ? 0.0005 inch, and the holes measured 0.2502, 0.2512 and 0.2505 inch). CONCLUSION: The +X COAS calibration discrepancies are attributed to an interference fit between the +X COAS adapter plate and panel 01, which was caused by the guide pin holes being too small. The interference fit would not allow the +X adapter plate to fit flat against panel 01, and in fact, the plate would seat differently depending on how much and where the mounting force was applied. This anomaly, most likely, has existed since OV-103's maiden flight (STS-41D); however, STS-29 was the first flight of OV-103 on which more than one +X COAS calibration has been performed on-orbit.
CORRECTIVE_ACTION: The +X COAS adapter plate guide pin holes on panel O1 will be reamed according to specification.
EFFECTS_ON_SUBSEQUENT_MISSIONS: None, multiple +X COAS calibrations have been performed on both OV-102 and OV-104 with no discrepancies observed.

Tracking No	Time	Classification	Documentation		Subsystem
MER - 0	**MET:** 001:17:48	Problem	**FIAR**	**IFA** STS-29-V-16	FC/PRSD
EECOM-03	**GMT:** 074:08:45		**SPR** 29RF16	**UA**	**Manager:**
			IPR 33RV-0009	**PR**	
					Engineer:

Title: Fuel Cell 1 Water Relief Valve Temperature Overshoot (ORB)

Summary: DISCUSSION: At approximately 74:08:45 G.m.t., the crew switched the fuel cell water relief heater from "A AUTO" to "B AUTO". The fuel cell 1 relief valve B thermostat immediately turned the heater on since its temperature was at the setpoint of 70?F. The temperature rose to 130?F before a normal cooldown of the valve was observed. Similar temperature spikes to 120-130?F were noted two more times during the mission. STS-26 data showed that this temperature never rose above 105?F when in a similar attitude. Although these temperature spikes were higher than previously experienced, this condition did not present any hazard to mission success or crew safety. Even if the heater had failed on, the condition would not have been hazardous.

The thermostat was removed and replaced at KSC prior to the STS-29 flight because of suspected damage incurred during turnaround operations. Troubleshooting at KSC revealed that the thermostat was loosely attached to the relief valve. In addition, this thermostat (S/N 418) had a turn-off point that was within specification, but was approximately 3-4?F higher than the typical turn-off temperature. CONCLUSION: The loose attachment of the heater B thermostat to the relief valve caused the heaters to warm the valve to a higher temperature before the thermostat could reach its turn-off temperature. This condition, coupled with the thermostat's slightly higher turn-off temperature resulted in the higher-than-anticipated fuel cell 1 water relief valve temperatures. CORRECTIVE_ACTION: The fuel cell 1 water relief valve heater B thermostat was reattached to the valve. EFFECTS_ON_SUBSEQUENT_MISSIONS: None.

Tracking No	Time	Classification	Documentation		Subsystem
MER - 0	**MET:** Prelaunch	Problem	**FIAR**	**IFA** STS-29-V-17	MPS
None	**GMT:** Prelaunch		**SPR** 29RF17	**UA**	**Manager:**
			IPR None	**PR**	
					Engineer:

Title: Slow Opening Time for LH2 Prevalve (ORB)

Summary: DISCUSSION: Data indicate that the Space Shuttle main engine (SSME) 1 liquid hydrogen (LH2) prevalve opened slowly when compared with data from previous flights and other engines on this flight.

These valves are commanded open to T-9.5 seconds and, per the specification should open within 1.5 seconds. Each valve contains two microswitches (A&B) that provide valve position measurements. However, these measurements are only sampled once per second and, therefore, are not an accurate indicator of opening response time. Measurements A and B were sampled at 2.16 seconds and 1.84 seconds respectively, and were found to indicate open at that time, while the previous samples approximately 1 second earlier still indicated closed. Initial open indications for SSME's 2 and 3 ranged from 1.08 to 1.60 seconds. On the previous flight of OV-103 (STS-26), the SSME 1 LH2 prevalve initially indicated open at 1.91 seconds. The above information suggests that the prevalve in question may have a slower-than-normal opening time, but does not indicate that it is out of specification. Per the OMRSD an opening response time test is performed during each vehicle flow. Additionally, the RSLS checks for an open indication 2.5 seconds after the command is issued. CONCLUSION: The SSME 1 LH2 prevalve prelaunch opening time was within the allowable limit. CORRECTIVE_ACTION: None. EFFECTS_ON_SUBSEQUENT_MISSIONS: None.

Tracking No	Time	Classification	Documentation		Subsystem
MER - 0	**MET:** Prelaunch	Problem	**FIAR**	**IFA** STS-29-V-18	OMS/RCS
None	**GMT:** Prelaunch		**SPR** 29RF18	**UA**	**Manager:**
			IPR	**PR** LP04-A0013	
					Engineer:

Title: Left Orbital Maneuvering Subsytem Fuel Gauge Erroneous Indication (ORB)

Summary: DISCUSSION: The left Orbital Maneuvering Subsystem (OMS) fuel probe gauge indicated an ungaugeable quantity pre-flight when the tank was about 5-percent full. Alternate loading techniques were used. During the OMS-2 burn, the quantity decreased to 45 percent, which is the start of the ungaugeable quantity area between the forward and aft compartments of the tank, and remained at this level through the rest of the burn and through the OMS-3 burn.

OMS propellant usage is calculated by the gauging totalizer during the first 15 seconds of each burn by reducing the amount of propellant at a preset estimated rate, and then uses the forward probe-sensed quantity. When the propellant quantity drops below 45 percent, the gauging totalizer receives the "dry" signal from the forward probe, adds the ungaugeable area quantity to the aft compartment quantity, and decreases this total channel quantity at a preset rate for 98 seconds (this process is referred to as the ungaugeable quantity countdown), after which the aft probe-sensed quantity is used. During the deorbit burn, the output showed the ungaugeable quantity countdown taking place, which indicates that the totalizer received the "dry" signal from the forward probe sometime after the 15-second gauging totalizer quantity calculation at the beginning of the deorbit burn. After the ungaugeable quantity countdown was finished, the total channel quantity output was correct. CONCLUSION: The output from the forward fuel probe was apparently biased high enough that the totalizer did not receive the "dry" signal from the probe until the propellant quantity dropped well below the level of the forward probe. CORRECTIVE_ACTION: The left OMS pod (LP04) has been removed from the vehicle and the forward fuel probe has been removed and replaced. Failure analysis will be tracked on CAR 29RF18. EFFECTS_ON_SUBSEQUENT_MISSIONS: None.

Tracking No	Time	Classification	Documentation		Subsystem
MER - 0	**MET:** Postlanding	Problem	**FIAR**	**IFA** STS-29-V-19	MECH
None	**GMT:** Postlanding		**SPR** 29RF19	**UA**	**Manager:**
			IPR	**PR** PYRO-0101, PVR-3-09-0101	**Engineer:**

Title: External Tank Aft Separation Hole Plugger Did Not Move Full Stroke. (ORB)

Summary: DISCUSSION: During the postflight inspection at Dryden Flight Research Center, it was discovered that the External Tank (ET) aft separation hole plugger did not fully extend the piston due to debris in the plugger. The debris was identified as part of the initiator, and no debris was found outside the cavity. This was the first failure since a design modification was completed prior to STS-26 to increase the spring load on the plugger (Reference MCR 11961). This modification has been implemented on all three vehicles. It is theorized that a part of the booster element (an internal part of the detonator system) lodged between the frangible nut and the hole plugger. The frangible nut secures the aft attachment; detonation splits the nut (inside the blast container) to allow separation. A similar incident happened during one of the certification program tests; this was verified by comparing photographs of this assembly with the hardware from the certification test.

CONCLUSION: The aft separation hole plugger was prevented from completing its full stroke due to a piece of debris which lodged in its path during separation. However, the hole plugger did prevent debris from escaping into the umbilical cavity, therefore its function was accomplished. CORRECTIVE_ACTION: Fly-as-is based on the following rationale: The interference with the hole plugger is a random occurrence. The probability of a fragment preventing ET door closure is considered remote. In addition, the vehicle moves away from any escaping debris during the ET separation phase. The escaped debris must abruptly change direction perpendicular to the original trajectory and then find its place in the clevis/rod to create a jam. Door mechanisms are almost totally enclosed with minimum linkage exposed. The doors can be recycled in flight if closing or latching is impeded. EFFECTS_ON_SUBSEQUENT_MISSIONS: None.

Tracking No	Time	Classification	Documentation		Subsystem
MER - 0	**MET:** 002:02:35	Problem	**FIAR**	**IFA** STS-29-V-20	OI - Recorders
INCO-07	**GMT:** 074:17:32		**SPR** INS-3-09-0392	**UA**	**Manager:**
			IPR 33RV-0008	**PR**	
					Engineer:

Title: Intermittent Inability to Dump OPS Recorder 1 Track 2. (ORB)

Summary: DISCUSSION: Between 074:17:32 and 074:17:49 G.m.t., attempts to dump operations (OPS) recorder 1 track 2 were unsuccessful both through the Tracking and Data Relay Satellite (Ku-band) and the Ground Space Flight Tracking and Data Network (S-band FM). The data on tracks 1 and 3 were dumped successfully. Later in the mission, OPS 1 track 2 was successfully dumped both through the Ku-Band and S-band. Based on this success, the decision was made to record entry data on OPS 1, including track 2 in parallel with OPS 2. However, during the post-landing dump, OPS 1 track 2 could not be dumped. Data on adjacent tracks were dumped and the same data on OPS recorder 2 were good.

A post-landing dump of OPS 1 track 2 through the T-0 umbilical interface was successfully performed and the data were determined to be good. Subsequent to this dump, a test was performed that recorded data on and dumped data from tracks 1 through 3 in both the forward and reverse directions. A total of 20 dumps were made during this test, 10 in the forward direction and 10 in the reverse direction, both through the OPS recorder direct T-0 umbilical interface and through the FM signal processor. The data were dumped successfully in all tests with no problems, and the dumped data were good. CONCLUSION: The anomalies experienced during STS-29 are unexplained. The most probable cause is ground station data "handling" problems that have been known to occur when the recorders switch tracks during a dump. CORRECTIVE_ACTION: None, fly as is. EFFECTS_ON_SUBSEQUENT_MISSIONS: None. Only one of two OPS recorders is required to be operational for flight per the Launch Commit Criteria. Operational instrumentation data and crew voice are recorded on OPS 2 (as well as OPS 1) and engine interface unit data (also recorded on OPS 1) are radiated to the ground in real-time via the FM signal processor.

Tracking No	Time	Classification	Documentation		Subsystem
MER - 0	**MET:** 000:00:09	Problem	**FIAR**	**IFA** STS-29-V-21	MPS
None	**GMT:** 072:15:06		**SPR** 29RF21	**UA**	**Manager:**
			IPR None	**PR**	
					Engineer:

Title: MPS LH2 Feedline Manifold Relief Valve Cycles (ORB)

Summary: DISCUSSION: During this period between main engine cutoff (MECO) and main propulsion system (MPS) propellant dump, the relief valve located on the

MPS 17 inch liquid hydrogen (LH2) feedline manifold cycled open one time. On the previous flight of OV-103 (STS-26), however, this same relief valve cycled four times. This event had no effect on the mission.

The number of relief valve cycles is a function of the pressure rise rate within the LH2 feedline manifold. Since only one cycle occurred on STS-29, it was initially thought that a known leak across the LH2 manifold 17-inch flapper valve (Flight Problem STS-29-12) may have contributed to a slow manifold pressure rise rate. Employing the 1080 scim leak rate measured postflight (assuming the leakage area remained constant), it was calculated that approximately 0.3 lb of LH2 leaked past the flapper during the period from ET separation to start of propellant dump through the fill and drain valves. This quantity is insignificant when compared to the approximately 100 lb of LH2 present in the manifold during this period. Therefore, it was concluded that the slow pressure rise was not a result of the 17-inch flapper leak. A review of past OV-103 flight data revealed that a slow pressure rise rate and decreased relief valve cycling is common, being seen on STS-51-G, 51-D, 51-A, 51-C, and 51-I. The faster pressure rise occurred on flights STS-26R and 41-D, only. The variation in pressure rise rate is attributed to relief flow across the LH2 prevalve from the Space Shuttle main engine to the manifold which varies from flight to flight. A higher flow across the prevalve into the manifold results in more frequent relief valve cycles. CONCLUSION: The operation of the LH2 feedline manifold relief valve was nominal during this flight. Fewer relief valve cycles are common on OV-103 and are most probably a function of relief flow past the LH2 prevalve. CORRECTIVE_ACTION: None. EFFECTS_ON_SUBSEQUENT_MISSIONS: None.

Tracking No	Time	Classification	Documentation		Subsystem
MER - 0	**MET:** Postlanding	Problem	**FIAR**	**IFA** STS-29-V-22	OI - Sensors
None	**GMT:** Postlanding		**SPR** 29RF22	**UA**	**Manager:**
			IPR	**PR** INS-2-08-0526	
					Engineer:

Title: Tire Pressure Measurement System Harness Separation (ORB)

Summary: DISCUSSION: The right-hand inboard tire pressure measurement system strain gage wiring and connector module (terminal board) came loose at touchdown and were found on the runway during the postlanding debris inspection. Normally, the connector module is installed in a bracket which is attached to the wheel with two screws. The modules were secured in the bracket ("U"-shaped clamp) by a tie down cord wrapped around the bracket. An inspection of the installations on all the wheels found the terminal boards on both left wheels to be in place and installed per the drawings. On the right side, however, one board was found to be missing and one was loose. The remaining board on the right side had not be spot-tied.

The wires are designed to break between the wheel and the strut at spin-up. The wires associated with the missing terminal board had also been broken on the wheel where they enter the brake cavity. Data were received from the sensors on all four wheels until main wheel spin-up indicating that the failure had not occurred before that time. Centrifugal force probably tore the connector module loose. Since the failure occurred after main gear touchdown and the function of this hardware is not required after main gear touchdown, there was no flight impact. As a related issue, it is believed that this loose harness may have caused the tile damage that was found aft of the right main landing gear door. CONCLUSION: Postflight inspection determined that the terminal boards on the right wheel terminal boards had not been tie-wrapped per the drawings. Further investigation of the tie-wrap design and procedures found that the tie-wraps were too short to be properly secured by the tool used for that purpose. CORRECTIVE_ACTION: A design change has been implemented to increase the lengths of the tie-wraps and to use double tie-wraps instead of single. This change has been implemented on OV-102 for the STS-28 mission. There is an existing Orbiter Maintenance Instruction (OMI S0004) that requires inspection of these installations. EFFECTS_ON_SUBSEQUENT_MISSIONS: Implement design change.

Tracking No	Time	Classification	Documentation		Subsystem
MER - 0	**MET:** Postlanding	Problem	**FIAR**	**IFA** STS-29-V-23	HYD
None	**GMT:** Postlanding		**SPR** 29RF23	**UA**	**Manager:**
			IPR	**PR** HYD-3-09-0282	
					Engineer:

Title: Hydraulic Leak in Aft Compartment (ORB)

Summary: DISCUSSION: During postflight inspection, approximately one-half to one ounce of free hydraulic fluid was found in the aft compartment. The fluid had leaked from a loose "B" nut in the leakage collection line from the Space Shuttle main engine-1 (SSME-1) accumulator.

This line collects fluid which has leaked from the SSME-1 accumulator seals, as some leakage is always expected. Hence, the fluid was not critical to the operation of the hydraulic power system. CONCLUSION: The free hydraulic fluid was normal hydraulic power system leakage that exited the leakage collection system through the loose "B" nut. No records of loosening the "B" nut during ground operations were found. CORRECTIVE_ACTION: The loose "B" nut was re-torqued and will be leak-checked during turnaround operations. If this problem should recur, only a small amount of fluid, similar to the quantity experienced, will be introduced into the aft compartment with no impact to the mission. EFFECTS_ON_SUBSEQUENT_MISSIONS: None.

Tracking No	Time	Classification	Documentation		Subsystem
MER - 0	**MET:** Postlanding	Problem	**FIAR**	**IFA** STS-29-V-24	D&C - Panels
None	**GMT:** Postlanding		**SPR** 29RF25	**UA**	**Manager:**
			IPR 33RV-0017	**PR**	
					Engineer:

Title: ORBITAL DAP - AUTO Light Off Auto Mode. (ORB)

Summary: DISCUSSION: During the crew debriefing, the crew reported that on one occasion the ORBITAL DAP - AUTO light on the aft panel (A6) was not illuminated while the corresponding light on the forward panel was illuminated. A lamp test was performed and it indicated that the lamp was operational. At a later time, the crew observed the aft ORBITAL DAP - AUTO light to be illuminated. No further anomalies were noted for the remainder of the flight.

Whenever, the "auto" mode is selected in the ORBITAL DAP, the flight software issues "light on" commands to both panels via separate multiplexers/demultiplexers (MDM's) and annunciator control assemblies (ACA's). The forward light is commanded via MDM FF1 and ACA 3. The aft light is commanded via MDM FF3 and ACA 4. MDM FF3 discrete outputs for this card and channel are not downlisted, therefore, no data are available for postflight analysis. There were, however, no indications of MDM errors or anomalies. Extensive troubleshooting at KSC failed to reproduce the anomaly. A similar problem occurred on STS-41D and again on STS-51C (1st and 3rd flights of OV-103) on a different ACA. In the previous case, the ROTATION; PITCH-PULSE light on Panel C3 was intermittent. Following STS-51C, two defective hybrid devices associated with the lamp driver were found in ACA 1. The devices were lost enroute to failure analysis, but it is believed that the failure was caused by either internal contamination or contamination introduced into the hermetically sealed hybrid through leakage around the glass-to-leads seal. Manufacturing methods and inspection requirements were changed in March 1985 to preclude these types of failures. This information is documented in CAR 20F007 which was closed on February 17, 1986. However, the use of presently delivered units was considered acceptable because the loss of any one channel will not have a significant effect on the mission as there are several redundant means to verify the more critical information. On STS-29, ACA serial no. 108018 was installed in slot 4. This ACA was manufactured in October 1980, and therefore, had not been manufactured with the improved methods and inspection requirements.   CONCLUSION: The cause of this anomaly is unknown. It was most probably caused by contamination in the lamp driver hybrid device.   CORRECTIVE_ACTION: None. Replacement of ACA4 in OV-103 is not considered warranted due to the fact that the anomaly is not repeatable and the questionable channel carries information which is available on the forward panel, on a CRT, and on the ground via telemetry.   EFFECTS_ON_SUBSEQUENT_MISSIONS: None.

Tracking No	Time	Classification	Documentation		Subsystem
MER - 0	**MET:** Postlanding	Problem	**FIAR**	**IFA** STS-29-V-25	TPS
None	**GMT:** Postlanding		**SPR** 29RF24	**UA**	**Manager:**
			IPR None	**PR**	
					Engineer:

Title: Aft Bulkhead Thermal Blankets Degraded. (ORB)

Summary: DISCUSSION: During the postflight inspection, six anomalous blankets were found. Four blankets, located at the top of the aft bulkhead (two on each side of the upper centerline), had a total of 15 snaps unsnapped. Also, two blankets located adjacent to and below the unsnapped blankets were torn. Previous flight experience (STS 41-G, STS 61-B, STS 61-C, STS-26, and STS-27) have found loose blankets due to snaps unbuttoned in areas similar to STS-29.

The payload inspection revealed a number of aluminized flakes. Further investigation indicated that the particles had originated from the aluminized Kapton used as a backside cover for the multilayer blankets on the aft bulkhead. Laboratory testing verified the identity of the particle material as Kapton. The blankets were examined and did not appear to have been crushed. Torn blankets have been evident on STS-26, STS-27, and STS-29 (no documentation on flights prior to STS-26). CONCLUSION: The exact cause of this problem has not been determined even though several hypotheses have been investigated by test and analysis. The redesigned blankets flown on STS-28, STS-30 and STS-34 demonstrates their compatibility with the existing environment. The loose snaps have no flight effect. CORRECTIVE_ACTION: The anomalous blankets and all others in this area have now been replaced with the redesigned blankets. This redesign adds vent screens and beta cloth material to the blanket backsides for additional strength. The beta cloth addition minimizes the wear during ascent, and if the material is damaged all of the aluminized Kapton particles will be contained. The condition of the modified blankets will be determined by inspection after each flight to assure that the blanket redesign is effective. EFFECTS_ON_SUBSEQUENT_MISSIONS: None.

Tracking No	Time	Classification	Documentation		Subsystem
MER - 0	**MET:** 000:00:14	Problem	**FIAR**	**IFA** STS-29-V-26	HYD
None	**GMT:** 072:15:11		**SPR** None	**UA**	**Manager:**
			IPR None	**PR**	
					Engineer:

Title: Hydraulic Systems 1 and 2 Bootstrap Pressures Locked Up Low (ORB)

Summary: DISCUSSION: Following auxiliary power unit (APU) shutdown at 072:15:11 G.m.t., the boot- strap accumulator pressures on hydraulic system 1 and 2 locked up at 2496 psia and 2464 psia, respectively. These values were below the minimum specification value of 2600 psid (reference to reservoir/return pressure). This anomaly had no impact on the mission.

A review of previous flight data showed that similarly low lockup pressures appeared in systems 1 and 2 after APU shutdown during the last flight of OV-103 (STS-26). Prior to STS-26, however, lockup pressures were within specification on these systems. Although the occurrence of a low reseat pressure followed by a rise in accumulator pressure is common throughout the past flights of all Orbiters, the reseat pressure on these last two flights of OV-103 are the lowest observed, indicating that the low lockup pressure is inherent to systems 1 and 2 of OV-103. After APU shutdown, the hydraulic system priority valve is designed to lock up the bootstrap system at a minimum value of 2600 psid when the supply pressure drops. Normally, at APU shutdown, the accumulator piston travels away from the gas side of the accumulator as a result of the drop in system pressure. Then, at priority valve lock-up (when the priority valve's internal relief valve reseats), the piston may overshoot, followed by a bounce back in the gas direction. Should piston stiction occur prior to the bounce back, the gas volume would be unnaturally expanded, and pressure would be lower than usual. (The accumulator pressure transducer reads gaseous nitrogen pressure only--there is no liquid-side pressure sensor). As the piston moves back toward the gas side, the gas volume would be compressed, and gas pressure would return to the expected priority valve reseat value (2600 psid minimum). Data show that the accumulator gas pressure returned to near the 2600 psid point within 10 minutes of shutdown with no accompanying thermal increase that would cause the change. Therefore, accumulator piston stiction may have been the cause of this low lockup pressure. The priority valve contains a check valve and a relief valve with common seats. Both valves are hollow, allowing pressure from the accumulator to reach the relief valve seat and pressure from the system to reach the check valve seat. The check valve is designed to open at APU start (exposing the bootstrap system to the main pump pressure) and reseat at 3 psid (referenced to system pressure). Some cycling of the check valve may occur as the hydraulic pump pressure fluctuates during APU operation. The relief valve is designed to open at 3000 psid (usually at APU shutdown) and reseat at a minimum of 2600 psid. For the relief valve to begin cycling, however, the check valve must be closed. If the check valve is open at APU shutdown, then the check valve reseat determines the lockup pressure of the bootstrap system. If the check valve is closed at APU shutdown, then the reseat of the relief valve determines the lockup pressure. In either case, a sluggish check valve or relief valve would cause a low lockup pressure. Prior to STS-26, all three OV-103 priority valves were removed and replaced. The replacement units were checked at the Kennedy Space Center but the reseat pressure was not recorded. The replacement units for systems 1 and 2 may have sluggish check valves or they may have relief valves that reseat at a lower value. The purpose of the bootstrap accumulator is to maintain pressure in the hydraulic reservoir which in turn provides suction pressure to the inlet of the main hydraulic pump. Suction pressure is necessary to prevent cavitation when the pump is started. Testing has shown, however, that both the main pump and the circulation pump can be started with a suction pressure as low as 15 psia, although neither pump is certified for this low of a pressure. This pressure may possibly be obtainable through intersystem leakage among the Orbiter hydraulic systems. Acceleration of the intersystem leakage may be required through operation of the circulation pumps or main pumps of the two good remaining hydraulic systems. If operation of the main pumps was required, then the start of the third (malfunctioning) system would be delayed until the required pressure of 15 psia at the main pump inlet was attained. Therefore, it is possible that an on-orbit failure of the bootstrap accumulator would not prevent hydraulic main pump operation. CONCLUSION: The hydraulic systems 1 and 2 bootstrap accumulator pressures most probably locked up below specification values after APU shutdown because of a accumulator piston stiction or low reseat pressure of the priority valve. CORRECTIVE_ACTION: Postflight testing will be performed with the system pressure being cycled up and down several times. A failure of the bootstrap pressure to return to specification value may result in the removal and replacement of the appropriate component. EFFECTS_ON_SUBSEQUENT_MISSIONS: NONE

Tracking No	Time	Classification	Documentation		Subsystem
MER - 0	**MET:** Postlanding	Problem	**FIAR**	**IFA** STS-29-V-27	GNC
None	**GMT:** Postlanding		**SPR** 29RF28	**UA**	**Manager:**
			IPR 33R-0007	**PR** COMM-3-09-0140	
					Engineer:

Title: TACAN 2 Loss of Lock After Landing (ORB)

Summary: DISCUSSION: Approximately 3 minutes after landing at Edwards Air Force Base (AFB) on runway 22, TACAN 2 unit lost lock in both range and bearing. The automatic gain control (AGC) reading indicated that a signal was present. This loss-of-lock condition persisted for about 30 minutes. TACAN 1 and 3 were both locked-on the ground station signal during this time.

The TACAN is designed to function in the air, where the main lobe of the ground station antenna is directed. The main lobe is set 4 to 8 degrees above the horizon depending on station use (terminal or enroute). The Edwards AFB ground station is located on a hill approximately 6 to 7 miles northeast and along the extended centerline of runway 22 (Shuttle runway). The Orbiter stopped runway 22 at a distance of 8 to 9 miles from the station. The station was behind the Orbiter, a location which creates

the worst possible look angles for the TACAN antennas. Additionally, the main lobe of the ground station was well above the Orbiter on the runway. The Base Operations buildings, hangers, and etc., were located to the right side and slightly behind the Orbiter in a location which provides an excellent source of reflected radio frequency signal from the ground station. Thus the Orbiter TACAN units may have received both the direct signal and reflected signals containing slightly different range and bearing information. This condition is called "multipath". If the TACAN units are locked on the ground station signal (tracking), range and/or bearing data may be maintained even in a multipath environment. However, if loss-of-lock occurs, reacquisition in a multipath condition may be difficult because of the differences in direct/reflected range and bearing data. The TACAN AGC voltage indicates relative signal strength of the received signal. When the TACAN 2 unit lost lock, the AGC voltage of all three TACAN receivers was similar while the Orbiter was on the runway indicating that all three units were receiving the ground station signal. The presence of an RF signal does not guarantee a range/bearing lock, if the multipath ambiguity exists. Extensive on-the-vehicle troubleshooting during postflight testing could not duplicate the problem. The TACAN 2 unit was removed and sent to the Rockwell Services Center for failure analysis. The unit passed all functional testing and was returned to service. CONCLUSION: The cause of TACAN 2 loss of lock was probably the result of a multipath condition aggravated by a less than optimum Orbiter antenna to ground station look angle. CORRECTIVE_ACTION: TACAN 2 unit (S/N 15069) was removed, and sent to the Rockwell Services Center for failure analysis. The units passed all functional test requirements and was returned to service. The results of this activity is further tracked by CAR 29RF28.
EFFECTS_ON_SUBSEQUENT_MISSIONS: None.

Tracking No	Time	Classification	Documentation		Subsystem
MER - 0	**MET:** 000:00:12	Problem	**FIAR**	**IFA** STS-29-V-28	MPS
None	**GMT:** 072:15:09		**SPR** 29RF29, 27RF05	**UA**	**Manager:**
			IPR None	**PR**	
					Engineer:

Title: Slow LH2 Outboard Fill/Drain Valve Closure (ORB)

Summary: DISCUSSION: The main propulsion system (MPS) liquid hydrogen (LH2) outboard fill/drain valve (PV11) closure time, as measured from issuance of the close command until reception of the closed position indicator, was 11.5 seconds when closed following the post-ascent MPS dump. Specifications required a maximum closing time of 10 seconds. Performance of the valve prior to and after this occurrence was nominal. This problem had no impact on the flight.

A similar problem occurred during STS-27 (OV-104 flight 3; flight problem STS-27-24). Postflight testing revealed that the valve actuator, which is the primary contributor for control of the valve response, was thermally sensitive. The valve consistently closed more slowly when at LH2 temperatures. Because of this, a Launch Commit Criteria (LCC) change was made to increase from 11 sec to 14 sec the time allowed for the LH2 outboard fill/drain valve to close when commanded at L-48 seconds. Testing has thus far been unable to determine the mechanism which produces the thermally sensitive actuator response. A teardown of the STS-27 actuator is to be performed. The LH2 fill/drain valve actuators used on all orbiters are of a type similar to those used on STS-27. These actuators incorporate an anti-slam modification which tends to produce slower response times than prior valves without the modification upon which the specifications were designed. The slower response time of these actuators is not considered to be a problem. CONCLUSION: The slowness of the LH2 outboard fill/drain valve during closure operations following the MPS dump was most probably due to an actuator which is sluggish at cryogenic conditions. Thermal sensitivity is considered to be a characteristic of the actuator and is not a problem. CORRECTIVE_ACTION: Removal and replacement of the actuator will depend on the results of the detailed analysis of the sluggish actuator from STS-27. If no abnormalities are found on the STS-27 actuator, the STS-29 unit will not be replaced. A change will be submitted to increase the specification for allowable closure time to 14 sec, matching the LCC requirement. EFFECTS_ON_SUBSEQUENT_MISSIONS: NONE

Tracking No	Time	Classification	Documentation		Subsystem
MER - 0	**MET:** Postlanding	Problem	**FIAR** JSC-EP-0108	**IFA** STS-29-V-29	GFE
NONE	**GMT:** Postlanding		**SPR** None	**UA**	**Manager:**
			IPR None	**PR**	
					Engineer:

Title: Wireless Crew Communication System Batteries (GFE)

Summary: DISCUSSION: Postflight, Mission Specialist 2 reported that the low battery alert tone came on shortly after initial use of the wireless crew communications system (WCCS). The batteries were replaced and about an hour later the alert tone came on again. A backup crew remote unit (CRU) with another battery was then used. This set also operated for about an hour and was subsequently stowed. Other crew members did not experience problems with WCCS batteries. Postflight, all WCCS units were found to be operating within specifications. The batteries, however, do have a history of problems with capacity. The batteries flown on STS-29 were manufactured with cells having a lot date of December 1987. Sample batteries yielded capacities in the range of 6 to 10 hours versus a specification value of 28 hours. Better cells (capacity of 28 hours) have been identified and these have lot dates of March 1988. An adequate supply of these cells are now available for the upcoming flights and the low-capacity batteries will be discarded. New batteries are being developed with greater capacities.

CONCLUSION: Two batteries provided sub-marginal capacity, but there were no other WCCS hardware problems. CORRECTIVE_ACTION: Batteries containing cells with a lot date of December 1987 will be discarded. Batteries having cells with a lot date of March 1988 will be flown until the new higher capacity units are available. EFFECTS_ON_SUBSEQUENT_MISSIONS: None.

Tracking No	Time	Classification	Documentation		Subsystem
MER - 0	**MET:** Postlanding	Problem	**FIAR**	**IFA** STS-29-V-30	MECH
None	**GMT:** Postlanding		**SPR** 29RF30	**UA**	**Manager:**
			IPR None	**PR**	
					Engineer:

Title: Right-Hand Outboard Brake Rotor Crack. (ORB)

Summary: DISCUSSION: During the postflight inspection of the right hand brake assembly at the vendor a crack in the number three brake rotor was discovered. The crack was discovered during x-ray inspection of the beryllium brake disks. The possibility of such an occurrence was evaluated prior to the flight when considering the planned braking Development Test Objective (DTO-0518 Braking System Test) and Flight Rule Change, and was determined not to be a flight safety issue. Braking capability was not reduced.

CONCLUSION: The crack was the result of the combined thermal and structural loads at landing and was not unexpected. CORRECTIVE_ACTION: Replace the rotor disk. All brakes are x-rayed and visually inspected prior to refurbishment and subsequently subjected to an acceptance test program (ATP).
EFFECTS_ON_SUBSEQUENT_MISSIONS: None